Ordering number : EN*A2268

LC898301AXA

Advance Information

ON Semiconductor®

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CMOS LSI

Liner Vibrator Driver IC

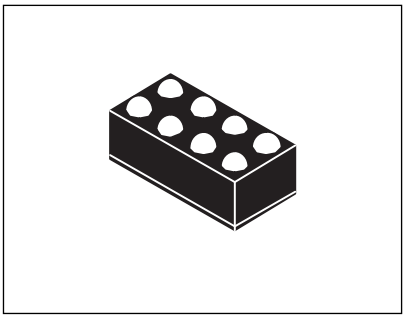
Overview

The LC898301AXA is a Linear Vibrator Driver IC dedicated to haptic feedback actuator and vibrator employed in mobile equipment. Due to the product superior technology, the drive frequency is automatically adjusted to the resonance frequency of the linear vibrator without the use of other external parts. As a result of this very effective drive, the vibration is as powerful as possible using very limited amount of energy compared to classical solutions.
The start time and brake time are fully configurable through the I^2C setting. Moreover, an automatic braking function has been implemented allowing to optimize the braking time.

Finally, a self test mode allows to detect various possible functional defaults during assembly.

Feature

1) Automatic adjustment to the resonance frequency for LRA (150Hz to 385Hz)
2) Programmable or Automatic braking
3) Initial drive frequency adjustment function
4) Adjustable Drive voltage through I^2C IF setting
5) EN IF or PWM IF driving mode available by automatic detection
6) Support various drive pattern through I^2C (1.8V IF)
7) Low power consumption thanks to the highly effective drive and the low power driving mode
8) Low driving noise (EMI, Audible band)
9) VBAT compliant
10) Thermal shutdown protection
11) Self test mode for defaults detection (open-circuit, short-circuit and weak back EMF)



WLCSP8, 0.78x1.58

Applications

1) Linear Vibrator (Vibration and haptics)
2) Mobile Phone
3) Portable Game
4) Mobile equipment with haptics function

* I^2C Bus is a trademark of Philips Corporation.

This document contains information on a new product. Specifications and information herein are subject to change without notice.

ORDERING INFORMATION

See detailed ordering and shipping information on page 12 of this data sheet.

Semiconductor Components Industries, LLC, 2013

Block Diagram

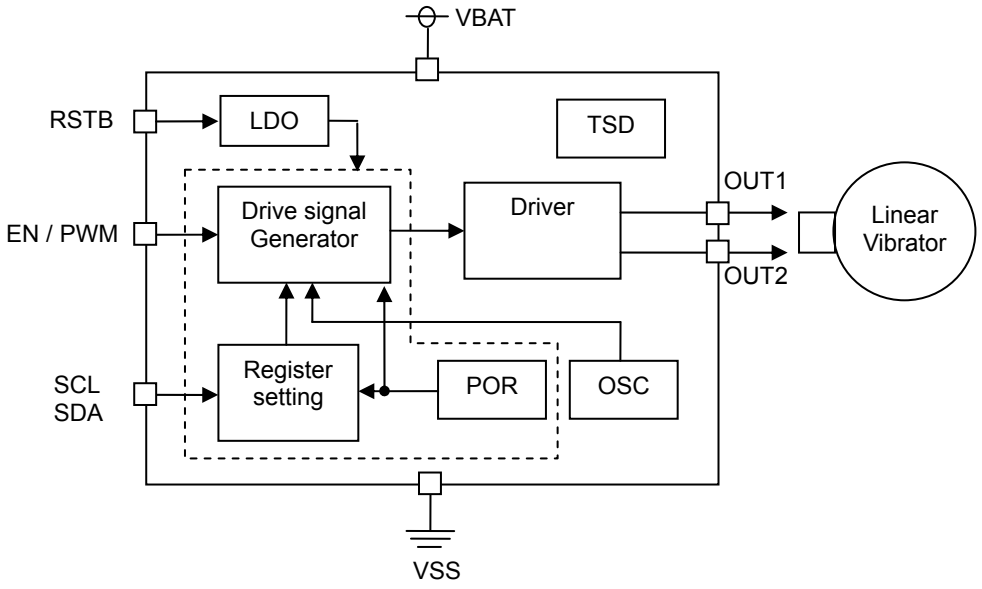


Fig. 1

Absolute Maximum Ratings at V_{SS} = 0V

Parameter	Symbol	condition	Rating	Unit
Supply voltage range	V_{DD}max		–0.3 to 6.0	V
Input voltage	V_{I1}	*1	–0.3 to V_{DD}+0.3	V
	V_{I2}	*2	–0.3 to 3.3	V
Output voltage	V_O	*3	–0.3 to 3.3	V
H-bridge Drive current	IOmax		200	mA
Allowable power dissipation	PDmax	Ta=85 °C, *4	140	mW
Operating temperature range	Ta		–30 to 85	°C
Storage temperature range	Tstg		–55 to 125	°C
Input or Output current	I_I,I_O	*5	±20	mA

*1 RSTB pin
*2 EN,SDA,SCL pins
*3 SDA pin
*4 glass epoxy (50mm × 40mm ,t=0.9mm, FR-4)
*5 Per an I/O buffer

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

Recommended Operating Conditions at Ta = –30 to 85 °C, V_{CC} = 0V

Parameter	Symbol	condition	Min	Typ	Max	Unit
Supply voltage range	V_{DD}		3.0	-	5.5	V
Input voltage range	V_{IN1}	*1	0	-	V_{DD}	V
	V_{IN2}	*2	0	-	1.98	V

*1 RSTB pin
*2 EN,SDA,SCL pins

Electric Characteristics

DC Characteristics at V_{SS} = 0V, V_{DD} = 3.0 to 5.5V, Ta = –30 to +85 °C

Parameter	Symbol	Condition	Min	Typ	Max	Unit	Applied pin
High level Input voltage	V_{IH}	CMOS	1.40	-	-	V	EN
Low level Input voltage	V_{IL}		-	-	0.32	V	
High level Input voltage	V_{IH}	CMOS Schmitt	1.50	-	-	V	SDA,SCL
Low level Input voltage	V_{IL}		-	-	0.24	V	
High level Input voltage	V_{IH}	CMOS Schmitt	1.50	-	-	V	RSTB
Low level Input voltage	V_{IL}		-	-	0.36	V	
Low level output voltage	V_{OL}	I_{OL}=4mA	-	-	0.4	V	SDA
Input leakage current	I_{IL}	V_I=V_{DD},V_{SS}	–10	-	+10	µA	RSTB,EN SDA,SCL

AC Input Characteristics at V_{SS} = 0V, V_{DD} = 3.0 to 5.5V, Ta = –30 to +85 °C

Parameter	Symbol	Min	Typ	Max	Unit	Condition
Input PWM frequency	I_{frq}	10.0	-	50.0	kHz	1%<PWM Duty<99%

Power Consumption at V_{SS} = 0V, V_{DD} = 3.0 to 5.5V, Ta = 25 °C

Parameter	Symbol	Min	Typ	Max	Unit	Condition
Stand-by current	P_{stb}	-	0.04	2.0	µA	RSTB="0"
Idle current	P_{idl}	-	2.7	-	mA	RSTB="1", EN="0"

Analog Characteristics at V_{SS} = 0V, V_{DD} = 3.7V, Ta = 25 °C

Parameter	Symbol	Min	Typ	Max	Unit	Condition
Output Voltage Difference OUT1 from OUT2	V_{out12}	-	2.7	-	Vpp	HBPW=max, VOSEL="00"
		-	2.9	-	Vpp	HBPW=max , VOSEL="01"
Adjustable resonance frequency range	F_{mo}	–10	-	+10	%	vs typ value

Pin Assignment

Pin List

I/O -> I : input, O: output, B: bi-direction, P: power supply, NC: not connected

NO	NAME	I/O	NO	NAME	I/O
1A	OUT1	O	1B	VDD	P
2A	OUT2	O	2B	RSTB	I
3A	GND	P	3B	EN	I
4A	SCL	I	4B	SDA	B

Pin Layout (PKG : WLP8, 0.4mm pitch)

SDA	SCL	**4**
EN	GND	**3**
RSTB	OUT2	**2**
VDD	OUT1	**1**
B	**A**	

< Bottom View >

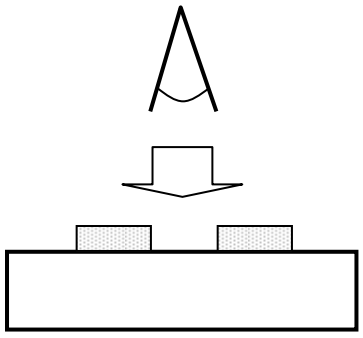


Fig.5

Pin Description

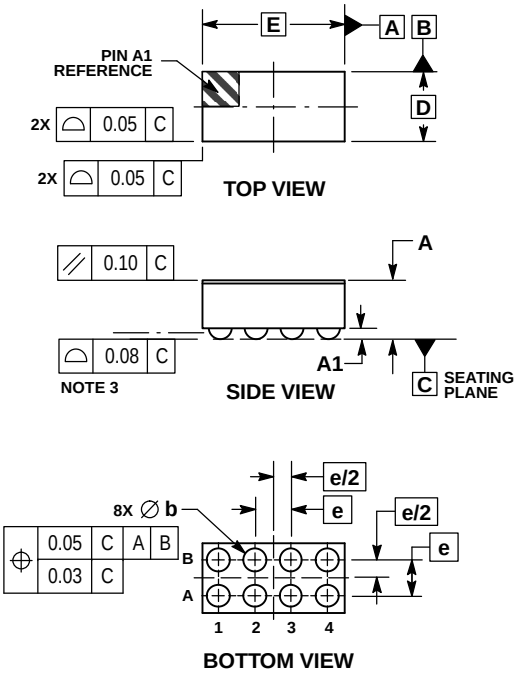
I/O -> I: input, O: output, B: bi-direction, P: power supply, NC: not connected

Signal name	I/O	Function	Remarks
OUT1	O	Motor drive pin	H-bridge output
OUT2	O	Motor drive pin	H-bridge output
RSTB	I	Reset and Standby control	L : enable, H : disable
EN	I	Motor drive ON/OFF	EN control or PWM control input
SCL	I	I^2C I/F clock pin	
SDA	B	I^2C I/F data pin	Open drain
VDD	P	Power supply pin	
VSS	P	GND pin	

Package Dimensions

unit :mm

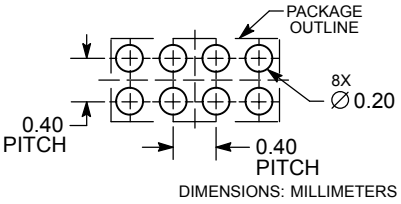
WLCSP8, 0.78x1.58
CASE 567HA
ISSUE O



NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. COPLANARITY APPLIES TO SPHERICAL CROWNS OF THE SOLDER BALLS.

	MILLIMETERS	
DIM	MIN	MAX
A	---	0.65
A1	0.07	0.17
b	0.15	0.25
D	0.78 BSC	
E	1.58 BSC	
e	0.40 BSC	

RECOMMENDED SOLDERING FOOTPRINT*



DIMENSIONS: MILLIMETERS

*For additional information on our Pb−Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

Timing Chart

Motor drive timing

The EN or PWM input mode is detected automatically after RSTB pin is set to “H”. IF the input mode detection is completed, the result is maintained until RSTB is set to “L”.

EN control mode

The Motor is controlled by EN signal, and the driving time is controlled by keeping EN pin “H”. The High speed start UP time, driving power and Brake time can be modified by I^2C setting. The initial driving frequency must be set by I^2C I/F at the center of resonance frequency of the linear vibrators, when the initial driving frequency is inadequate. The minimum width of EN signal must be larger than the cycle of initial driving frequency setting.

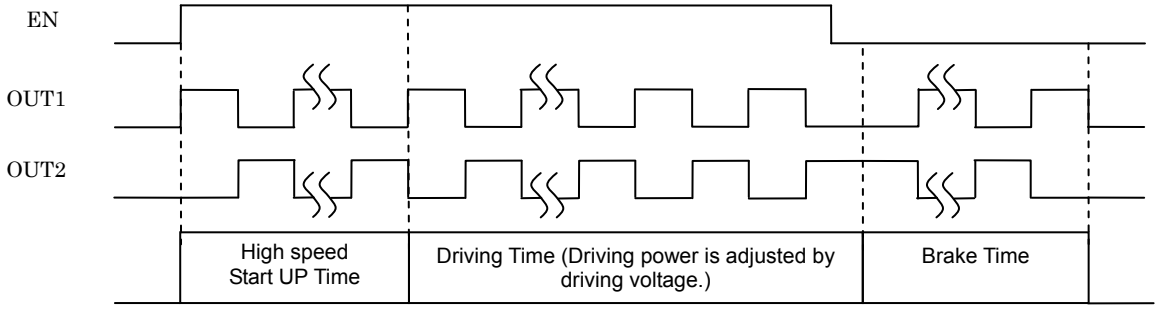


Fig 8.1

Stand-by Control (EN control mode)

The Stand-by mode is controlled by RSTB pin. (RSTB=”L” → Stand-by mode is ON.)
When the stand-by mode is “ON”, the register value is set to initial value. So, the register must be set again after the stand-by mode is “OFF”. And, the “EN” signal and I^2C command must wait over 200μs after “RSTB” pin is set to “H”.

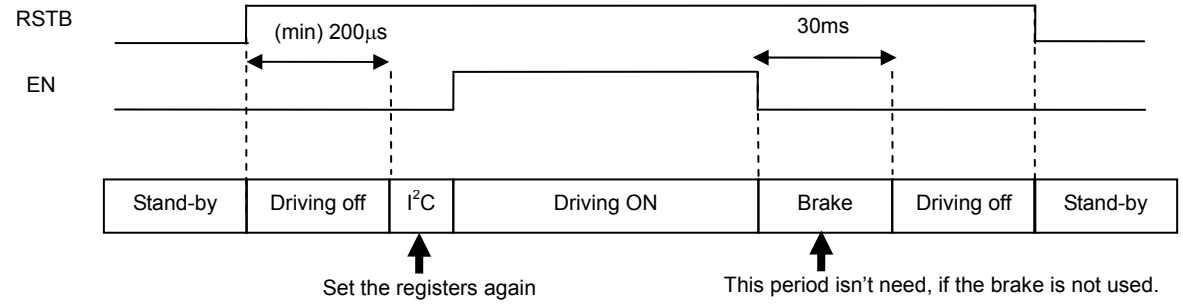


Fig 8.2

EN control

The minimum time of EN=”H” is (1/ the frequency: RESOFRQ). ex) 0x02 RESOFRQ=0x0A (175Hz) → (min) 5.71ms
EN=”L” just after EN=”H” means brake works. So the minimum time of EN=”L” depends on the remains of vibration. Then when drive time until just before EN=”L”(time of EN=”H” before EN=”L”) is over 30msec, the minimum time of EN-“L” is 30msec.
When drive time until just before EN=”L”(time of EN=”H” before EN=”L”) is less than 30msec, the minimum time of EN=”L” is the same time as drive time until just before EN=”L”.

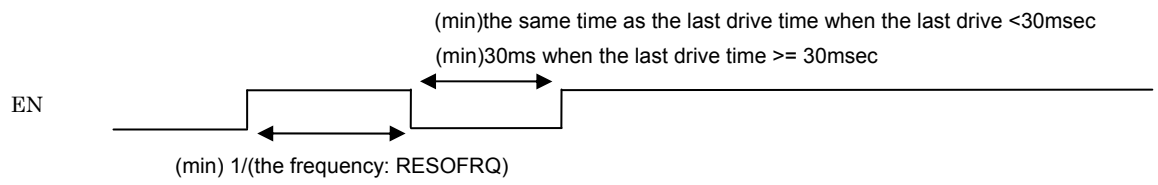


Fig 8.3

PWM control mode

On this mode the motor is controlled by “PWM” signal, and it is automatically detected. The driving or brake mode is judged by the duty of “PWM” signal. Also the driving power is judged by it. The judgment rule is decided by the table as below. On this mode, 0×05 to 0×09 registers are available, and the PWM input duty is limited between1% to 99%.When the duty is 0%, the driving is stopped.

Note) PWM input frequency must be set 128*(Resonance frequency of LRA) in case 0×08: RFSEL is set to ”0”.

Note) The actual driving frequency of the LRA is calculated by Auto Tune function.

Note) The period of input PWM detection is about 170μs after a signal input.

Duty(%)	Driving mode	resolution
99.00 to 50.39	Forward	127 steps
50.39 to 49.62	Stop	-
49.62 to 1.00	Reverse	127steps

Note) Duty:99.0% is maximum driving, on the other hand, Duty:1.0% is maximum braking.

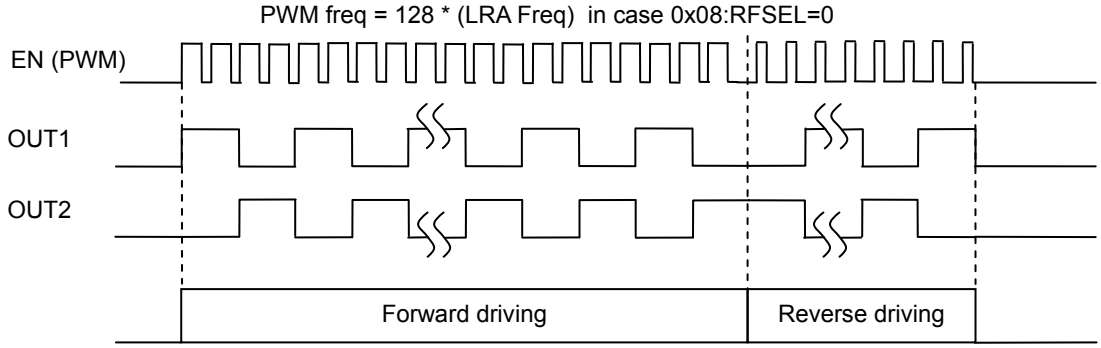


Fig.8.4

Stand-by Control (PWM control mode)

The Stand-by mode is controlled by RSTB pin. (RSTB=”L” → Stand-by mode is ON.)

When the stand-by mode is “ON”, the register value is set to initial value. So, the register must be set again after the stand-by mode is “OFF”. And, the “EN” signal and I^2C command must wait over 200μs after “RSTB” pin is set to “H”.

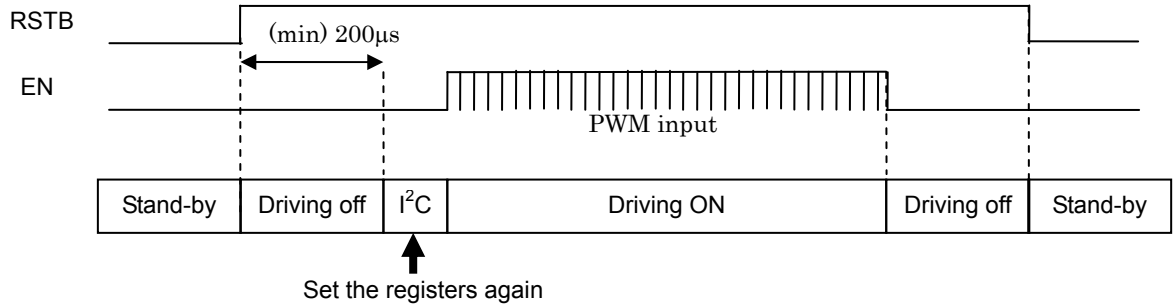


Fig 8.5

I²C Serial Interface

Writing format (Sequential Writing is possible)

After the start condition, slave address (7bit) and “L”(Write mode) are received , the flag “ACK=L” is replied. Next, after the 8bit address is received, the flag “ACK=L” is replied. Next, after the 8bit write data is received, the flag “ACK=L” is replied. Next, when the stop condition is received, the write data can be written in the specified address. Moreover, it is possible to write data in the incremental address by the continuous input of the 8bit data confirming the flag “ACK=L” after the every 8bit write data input.

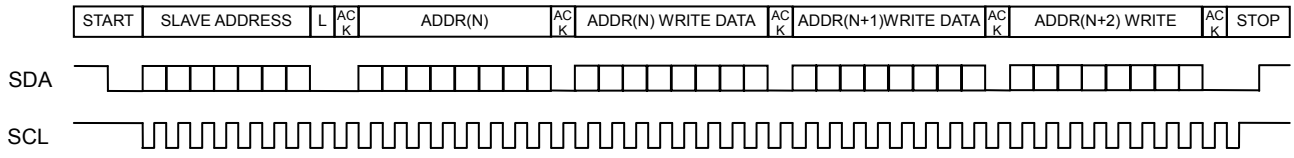


Fig 8.6

Reading format (Sequential Reading is possible)

After the dummy writing, the start condition, slave address(7bit) and “H”(Read mode) are received, the flag “ACK=L” is replied. Next, the 8bit read data is output. After them, when the stop condition is not received, and the read condition is continued, the read data of incremental address is output one by one. The read condition is end when the end condition is received after the flag “ACK=H”.

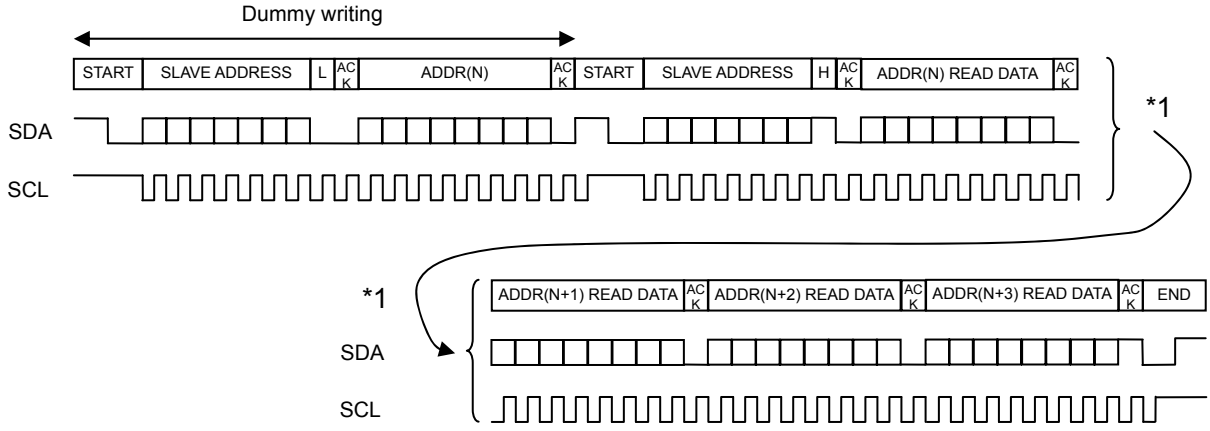


Fig 8.7

Slave Address

The Slave Address is as follows.

Slave Address	1001001

AC Characteristics (I^2C Serial Interface) at V_{SS}=0V, V_{DD}=3.0 to 5.5V, Ta=–30 to +85ºC

Parameter	Symbol	Pin	Min	Typ	Max	Unit	comment
SCL Clock Frequency	f_{SCL}	SCL	-	-	400	kHz	
START condition Hold time	$t_{HD;STA}$	SCL SDA	0.6	-	-	μs	
SCL clock Low width	t_{LOW}	SCL	1.3	-	-	μs	
SCL clock High width	t_{HIGH}	SCL	0.6	-	-	μs	
RE-START condition Setup time	$t_{SU;STA}$	SCL SDA	0.6	-	-	μs	
SDA Hold time	$t_{HD;DAT}$	SCL SDA	0	-	-	μs	
SDA Setup time	$t_{SU;DAT}$	SCL SDA	0.2	-	-	μs	*1
SDA, SCL Rise time	tr	SCL SDA		-	0.3	μs	*1
SDA, SCL Fall time	tf	SCL SDA		-	0.3	μs	*1
STOP condition Setup time	$t_{SU;STP}$	SCL SDA	0.6	-	-	μs	
STOP to START BUS open time	t_{BUF}	SCL SDA	1.3	-	-	μs	

*1) Design Assurance (Shipment test none)

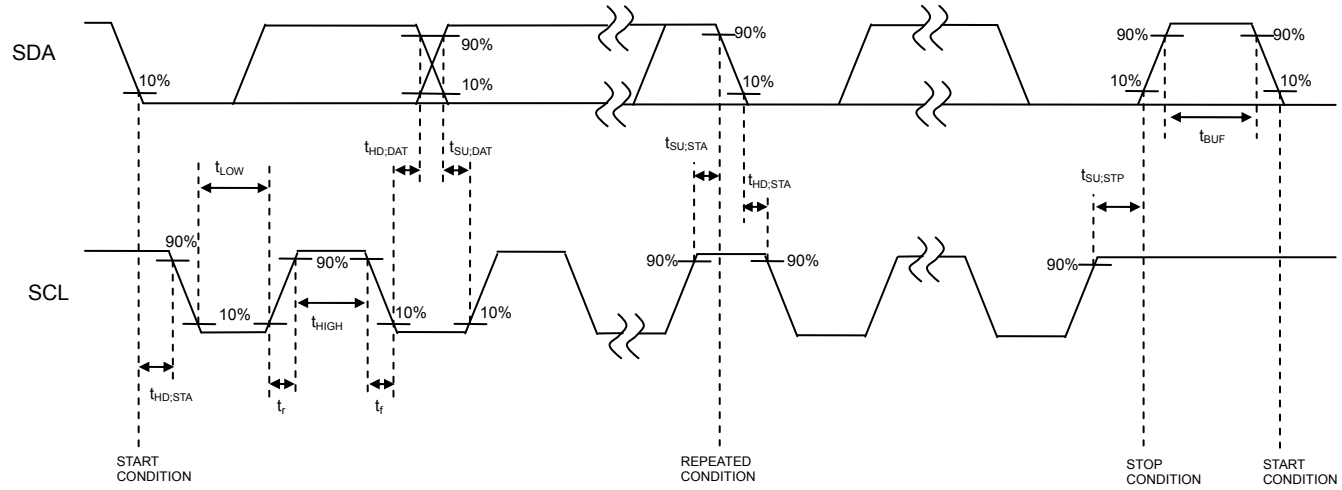


Fig 8.8

AC Characteristic (Power On Reset) at V_{SS}=0V, V_{DD}=3.0 to 5.5V, Ta=–30 to +85ºC

Parameter	Symbol	Min	Typ	Max	Unit	comment
RSTB input timing	T_{RSTB}	1.0	-	-	μs	-

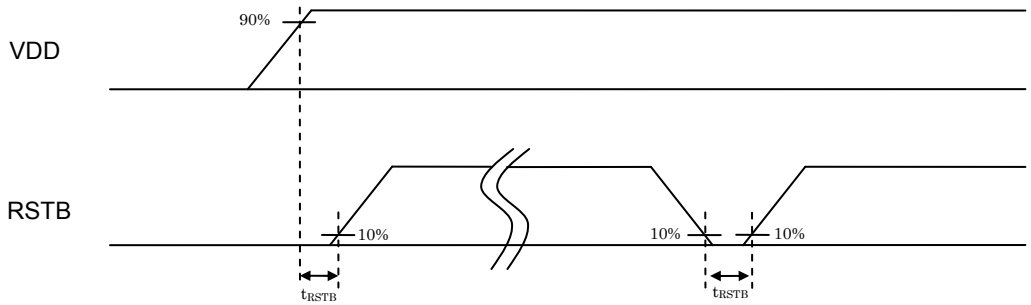
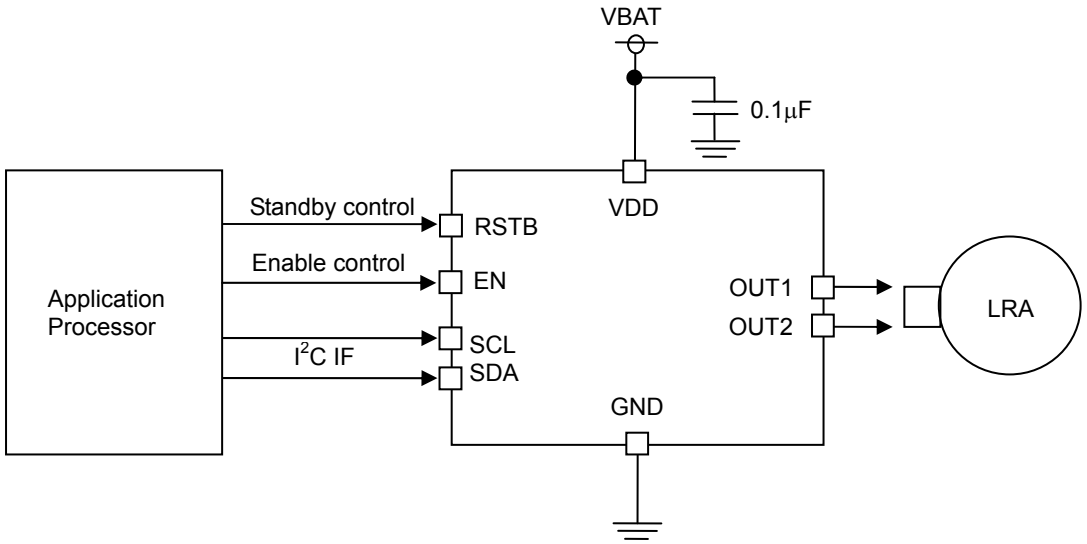


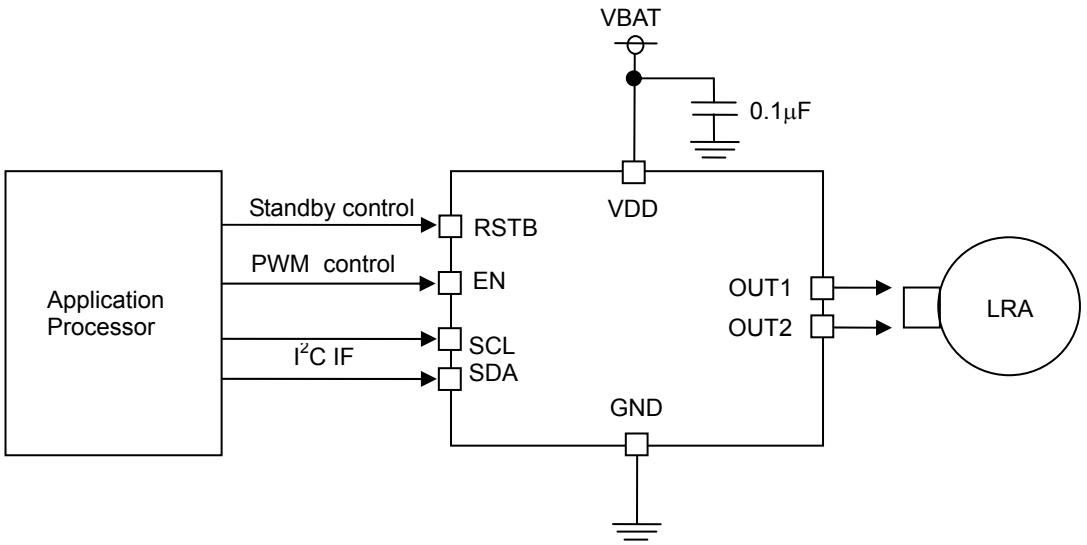
Fig 8.9 RSTB input timing chart

Application Information

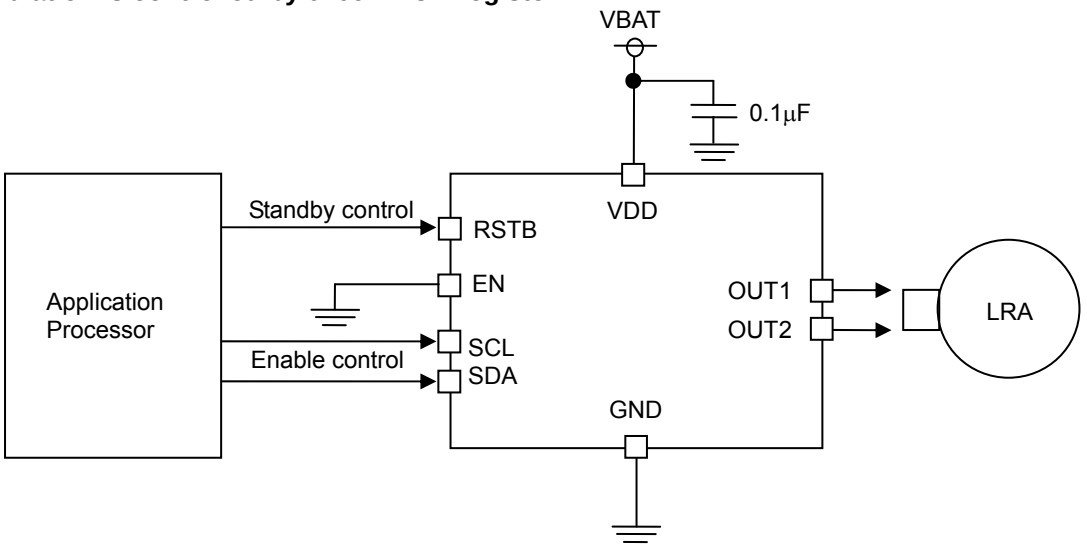
1) A vibration is controlled by EN & RSTB pin.



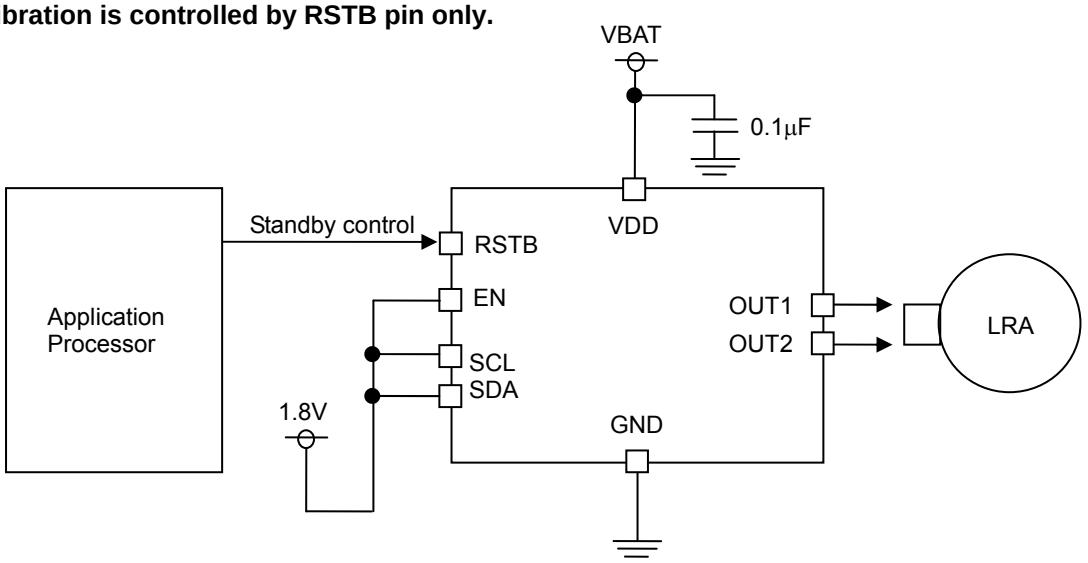
2) A vibration is controlled by PWM input RSTB pin.



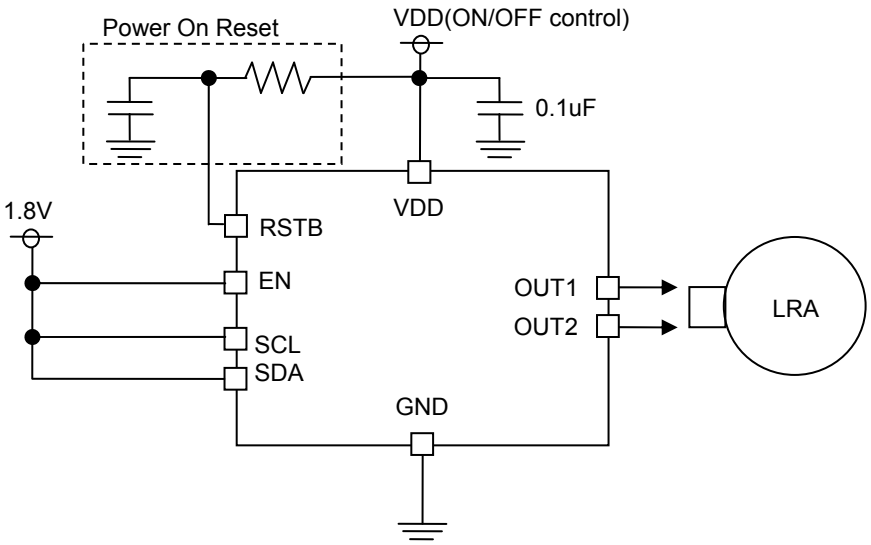
3) A vibration is controlled by 0x09 ENON register.



4) A vibration is controlled by RSTB pin only.



5) A vibration is controlled by V_{DD} supply only.



ORDERING INFORMATION

Device	Package	Shipping (Qty / Packing)
LC898301AXA-MH	WLCSP8, 0.78x1.58 (Pb-Free / Halogen Free)	5000 / Tape & Reel

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